Thermatrix Flameless Thermal Oxidizer Technology

An Innovative Method for Treating VOC Vapors

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ABSTRACT

This is one of a series of fact sheets that shares information on successful technologies domonstrated and strategies applied at Naval Air Station (NAS) North Island through the Navy Environmental Leadership Program (NELP). The intent of these fact sheet is to encourage other Naval Installations to consider these technologies and strategies at their facilities.

This fact sheet provides information on the Thermatrix, Inc. (Thermatrix) flameless thermal oxidizer, an innovative and cost-effective treatment technology for volatile organic compound (VOC) vapors. This technology was demonstrated at NAS North Island where vapors generated during the transfer and dispensing of JP-5 were treated in the Thermatrix unit over a 3-month period. Results indicated an average destruction and removal efficiency (DRE) of 99.993 percent of VOCs measured as total hydrocarbons, exceeding the primary objective of 99.99 percent DRE. Concentrations of nitrogen oxides (NO_x) and carbon monoxide (CO) were well below the primary objectives. The demonstration unit cost $50,000 for the equipment and predicted operation and maintenance costs are approximately $11,275 per year.

BACKGROUND

On October 23, 1994, the Secretary of the Navy approved the NELP for implementation at NAS North Island and Naval Station Mayport in Florida. NELP was established to find innovative, cost-effective ways to manage environmental programs at Navy bases. NELP initiatives at NAS North Island, focus on identifying and demonstrating innovative and cost-effective cleanup, compliance, conservation, and pollution prevention technologies and controls that will have broad applications Navy-wide.

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The NAS North Island Fuel Farm area, located at the northwestern corner of the base, houses a number of fuel transfer operations which are known sources of fugitive VOC emissions. Tank 1009, an underground JP-5 fuel storage tank located at the Fuel Farm, was selected as the vapor source for the demonstration because the transfer and dispensing of JP-5 is a frequent activity for this tank and the resulting emissions provide an adequate flow rate and concentration of VOCs for a technology demonstration. During normal filling, vent gas from Tank 1009 is discharged from dual elevated pressure-vacuum relief vents to the atmosphere.

TECHNOLOGY DESCRIPTION

The Thermatrix flameless thermal oxidation technology uses a non-flame, packed-bed oxidizer to destroy VOCs (Figure 1). According to Thermatrix, organic emissions amenable to treatment using this system include aromatics, olefins, paraffins, ketones, alcohols, and chlorinated solvents. The unique feature of the oxidizer is its use of a hot, stationary bed of inert ceramic material. The ceramic matrix provides turbulence for the mixing of gases and, therefore, the oxidizer does not rely on flame for gas mixing. The ceramic matrix also provides consistent temperatures and ensures complete oxidation of hydrocarbons. The large heat sink provided by the ceramic matrix allows the oxidizer to treat waste fumes from either continuous or batch processes. Since the bed is composed of chemically inert material and is not catalytic, the oxidizer can handle a wide variety of VOCs. Performance of the bed is maintained throughout the life of the system. In contrast to catalytic oxidizers, pressure drop across the system is very low due to the high void space ratio (approximately 70 percent) in the matrix. Also, due to much lower peak temperatures than those experienced with incineration, insignificant formation of NO_x and carbon monoxide CO are typically expected to occur during oxidation. If chlorinated hydrocarbons are present in the VOC stream, a scrubber to remove acid gas from the thermal oxidizer exhaust can be provided if needed.

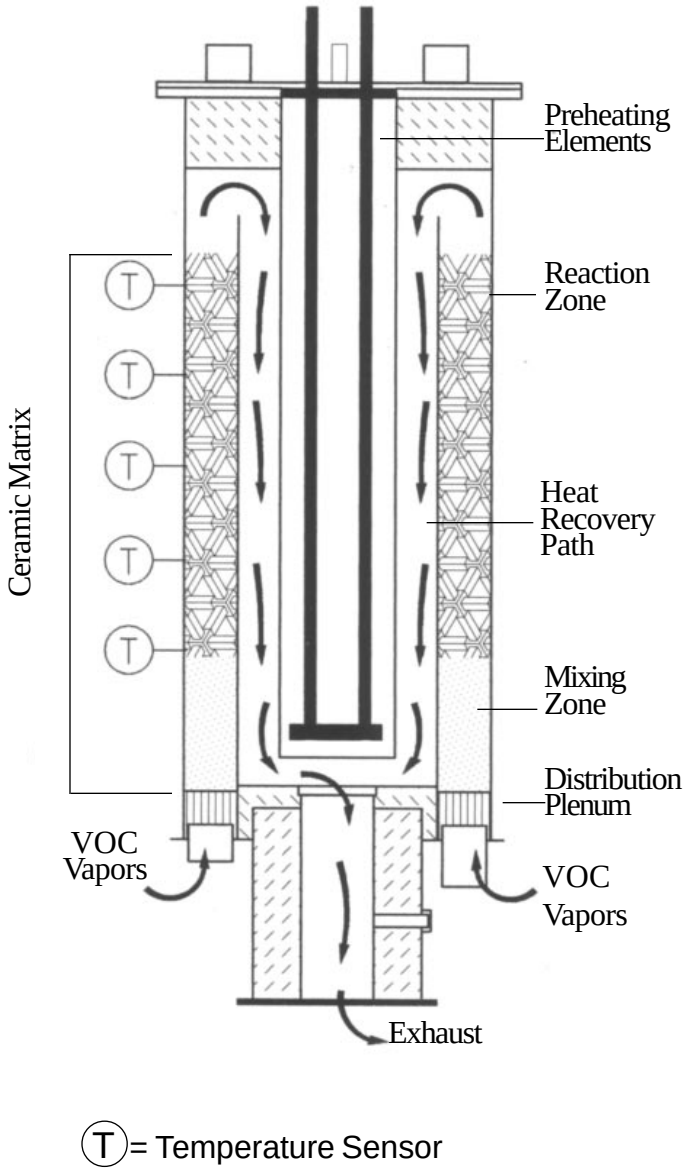


Figure 1 - Thermatrix Flameless Thermal Oxidizer

In operation, the VOC process stream and air necessary to support the oxidation enter the oxidizer and flow into the ceramic matrix, which has been preheated to temperatures typically between 1600-1850 degrees Fahrenheit. As the vapor stream moves through the interstitial spaces of the ceramic matrix, turbulence results in thorough mixing of oxygen and organic chemicals within the mixing zone. The tortuous pathway also provides for heat transfer between the gas and the bed material. The temperature of the gas increases until the oxidation temperature of the organic chemicals is attained. Once the oxidation temperature has been reached, the VOCs in the process stream oxidize in a reaction zone and release heat. A portion of the heat released from the oxidation reaction is absorbed by the ceramic bed to maintain the reaction zone temperature. Both internal and external heat recovery are available on larger capacity units, if desired. The thermal mass of the ceramic matrix allows the unit to efficiently remain in standby mode during treatment of intermittent streams.

Control of the oxidation process is fully automated; thermocouples are used to measure the temperature profile in the reaction zone. The oxidizer control system will allow heat or air to be added in order to maintain the reaction zone in the appropriate geometric location within the unit. If the flow or concentration of the inlet stream increases substantially, dilution air is added automatically at the mixer to keep the reactor at the operating temperature range. If the process stream lacks sufficient internal energy to maintain the ceramic matrix temperature, thermal energy is automatically introduced into the system. The control system also includes limit switches and alarms that will automatically shut down the unit and activate the appropriate annunciator lights on the control panel when an abnormal condition occurs.

OPERATIONAL REQUIREMENTS

The ES-300H thermal oxidizer demonstrated at NAS North island was vertically mounted on a 2-foot by 4-foot skid. A portable air compressor capable of providing at least 13 standard cubic feet of clean, dry, oil-free air at 80 pounds per square inch (gauge) is required to purge the oxidized vapors from the unit and the control panel. Both the oxidizer and the air compressor were secured to a concrete pad. Polypropylene tubing (1-inch diameter) was used to connect the tank vents to the thermal oxidizer inlet ports.

The ES-300H unit typically requires 240-volts alternating current (AC), single -phase electrical power. The unit draws 20-amperes when the internal heating elements are operating at 100 percent (mostly during the initial warm-up period.) The total electric power requirement for the thermal oxidizer unit and the air compressor during the demonstration period was 113 kilowatt hours per day.

DEMONSTRATION RESULTS

The demonstration objectives for the Thermatrix flameless thermal oxidation unit were primarily to assess its effectiveness in destroying VOC vapors from JP-5 while not producing NO_x and CO above regulatory pollutant levels. This was done by measuring DRE of total hydrocarbons (THCs), and verify that the unit did not generate more than 2 parts per million (ppm) of oxides of NO_x and 10 ppm of CO.

The technology demonstration took place from June to September 1995. The results indicated the DRE of THC for the Thermatrix flameless thermal oxidation exceeded the current requirement for hazardous substance incineration of 99.99 percent by achieving an average DRE of 99.993 percent. The average NO_x concentration from the unit was 0.65 ppm (corrected for 15 percent O_2), well below the local regulatory requirment of 2 ppm. Also, the average CO concentration from the unit averaged 2.0 ppm, well below the local regulatory requirment of 10 ppm.

BENEFITS

√ *No Residuals.* The Thematrix unit completely oxidizes organic vapors. The chemically inert ceramic matrix remains in the unit throughout the life of the system leaving no treatment, or operational residuals for disposal.

√ *Efficient Operation.* Once the operational temperature is reached, the heat released from the destruction of the organic vapors is absorbed by the ceramic matrix. This allows the unit to remain in standby mode during treatment of intermittent vapor streams with minimal external thermal input.

√ *Fully Automated.* The oxidation process is fully automated and controlled by a programmable logic controller (PLC). The PLC will compensate for a reduction in the ceramic matrix temperature and add dilution air if necessary.

√ *Easily Implemented, operated, and maintained.* The thermatrix unit is easy to install and requires minimal operational support, and maintenance.

√ *Versatile.* The Thermatrix technology is being used commercially to destroy chlorinated VOCs and polycholrinated biphenyls (PCBs).

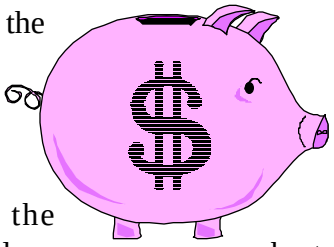
LIMITATIONS

The demonstration was performed on a relatively low concentration VOC vapor stream in relatively high oxygen containing system (18 percent by volume). It is not known how the system will operate with a organic-rich stream and/or an oxygen-deficient environment.

The small size of the unit (300 standard cubic feet per minute) used in the demonstration does not allow scale-up to VOC treatment costs in terms of dollars per ton of VOC removed.

COSTS

Thermatrix representatives have indicated that the capital cost for the system demonstrated at NAS North Island was approximately $50,000. Costs for larger capacity models would understandably be higher. Operating costs involve only the cost of 24-hour electrical power, since the unit was designed to operate unattended. Using an average power consumption of 113 kWh per day based on the NAS North Island NELP demonstration and assuming $0.06/kWh, electrical power costs were estimated to be $6.78 per day or $2,475 per year. Note that this estimated power cost includes operation of an air compressor as well as the thermal oxidizer. Continuous operation of the oxidizer, rather than the intermittent operation experienced during the demonstration, would provide more heat absorption in the ceramic bed from oxidation reactions and would consequently result in less cooling from ambient air and a lower power demand for electrical heating.



Annual costs for emission monitoring were estimated at $6,300, based on 180 man-hours per year at $35/man-hour. Maintenance costs, which were assumed involve periodic inspections of the unit and replacement of failed components, were estimated to be $2,500 per year.

SOURCES OF ADDITIONAL INFORMATION

Additional information on the Thermatrix flameless thermal oxidation technology demomstration can be obtained from:

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Additional information about the Navy Environmental Leadership Program can be obtained on the Internet WWW Site at:

http://nasni.navy.mil/~nelp/nelp.htm

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